Submission in Response to NSF CI 2030 Request for Information

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Research Domain, discipline, and sub-discipline

Oceanographic Research, All disciplines

Title of Submission

Oceanographic Research and the Need for More Satellite Bandwidth

Abstract (maximum ~200 words).

The digital age, long an integral part of business on land, has become an ever increasing necessity for life at sea with marine vessels becoming more dependent on integrating with shore-based systems and with on-board technology which have advanced markedly over the traditional systems used just five years ago. In order to keep up with these changes, science parties need sufficient bandwidth and cyberinfrastructure for telepresence, data transfers for real-time modelling, and collaboration with peers; a ship's crew members need sufficient bandwidth for charting, telemedicine, modern equipment maintenance, and institutional business. Regrettably, satellite bandwidth is one of the most limited resources at sea, and as such hampers the ability for all to succeed.

Question 1 Research Challenge(s) (maximum ~1200 words): Describe current or emerging science or engineering research challenge(s), providing context in terms of recent research activities and standing questions in the field.

Modern ships require 24/7/365 bandwidth and connectivity to operate as scientific research vessels. The current allotted bandwidth is insufficient at best. The time devoted by ships' technicians to manage the limited bandwidth is ever increasing, and detracts from the ability to meet scientific objectives, including outreach events.

A majority of science cruises now include an outreach component. The goal is to bring the real-time science into the classroom and out to the public at large, encouraging support for the scientific community as a whole. With the current bandwidth allotment, and media outlets requesting live feeds for interviews and press releases, it is often a struggle to get even pre-recorded video clips ashore in a timely manner for same-day delivery, much less real-time interactive sessions.

A great deal of technician time is spent educating science regarding these limits, and chasing down "rogue" computers that take over the

bandwidth due to preinstalled cloud applications and forced updates. With more bandwidth, uplink lines would not be saturated with uploading to the cloud and would grant shore personnel more consistent connections to manage the ship's network,freeing up the technicians to assist with science.

The ability for multi-ship, multi-disciplinary science projects to share entire datasets collected will allow for more informed cruise planning with respect to choices in, but certainly not limited to, AUV and mooring deployments, and capitalizing on key areas of interest. In addition, many scientific missions could be complemented with expert knowledge from scientists ashore should they have increased access to near-live data.

Question 2 Cyberinfrastructure Needed to Address the Research Challenge(s) (maximum ~1200 words): Describe any limitations or absence of existing cyberinfrastructure, and/or specific technical advancements in cyberinfrastructure (e.g. advanced computing, data infrastructure, software infrastructure, applications, networking, cybersecurity), that must be addressed to accomplish the identified research challenge(s).

As research vessels' infrastructure ages, and the science instrumentation evolves, the gulf between is becoming more evident. Data collectected from modern systems, including high resolution acoustics/radar (EK80, EM122, EM710, WaMOs) and high definition video (ROV/AUV mounted 4k cameras), are overwhelming the cyberinfrastructure on research vessels. Storage and transfer of these large datasets has become a real challenge. The current data rates desireable for modern 4K cameras on these vehicles are greater than 1Terabyte per hour. Although vehicle teams are fairly self-sufficient in many respects, there is no getting around some level of interface with a ship's cyberinfrastructure in order to receive instrument feeds, deliver data to the science party, keep up with their own technical support requirements, and accomplish the mission.

The infrastructure needs to support not only ever-expanding data storage requirements, but also the processing power, network hardware, and modern cabling required to manipulate these data sets efficiently.

Modern instrumentation systems are also becoming extremely complicated and require experience and knowledge to run them in a fashion where the data collected is meaningful. Access from shore to assess data integrity would save time and money, however the limited bandwidth makes this a difficult task. If data could be processed shipboard by an expert on shore, it could be used to make more informed research decisions during the cruise.

Remote server administration is also becoming increasingly critical as cybersecurity challenges present a daunting task for even full-time cybersecurity experts, let alone sea-going technicians. Remote administration for updating cybersecurity, firewalls and diagnosing routing issues can be a big help to the shipboard technicians. With the aforementioned complexity of scientific and marine equipment, it is becoming increasingly rare to find the technician who has, firstly, the knowledge and, secondly, the available time to meet all these demands. Increased access to shore would alleviate some of this pressure on our technicians.

As with all technical sectors of industry and research, there has to be necessary preparations in anticipating the growth of these hardware requirements to ensure that systems are not installed with a fear of becoming obsolete in only a few years.

Question 3 Other considerations (maximum ~1200 words, optional): Any other relevant aspects, such as organization, process, learning and workforce development, access, and sustainability, that need to be addressed; or any other issues that NSF should consider.

Life has become digitized and dependent on access to the Internet. Consistent shore connection is being viewed by most mariners and scientific personnel as a substantial ease on the pressure of living at sea for long uninterrupted periods. Additionally, there are numerous examples of systems that simply would not function to expectation without a reliable internet connection.

Ship's hospitals are currently equipped with internet-connected devices (Tempest) to send patient vitals ashore for diagnosis. These systems have the capability to use video and high resolution pictures to help shore medical personnel diagnose illness and treat injuries,

however with the current bandwidth these features are unable to be utilized.

Basic ship infrastructure is being equipped with shore support modules built in as part of the ship systems. The current automation systems require occasional remote logins by the manufacturer, and the newer generator installations require internet access for diagnosis and troubleshooting.

Paper charts and manuals are being phased out and in some cases are only available digitally. With the current bandwidth it can take hours to download a manual or a chart. The United States Coast Guard (USCG) is currently implementing an all electronic charting display and information system (ECDIS). ECDIS regulations require regular chart correction downloads, even paper charts currently have corrections issued electronically.

Fleet management software needs to sync with the shore server to manage purchasing, preventative maintenance, dry docking, hull inspection, document control and inventory control, as well as crewing requirements and payroll.

Home institutions are requiring personnel to login to the shore websites for travel requisitions, benefit updates and changes, and human resource access. A good example is the ‘conflict of interest’ forms (required for certain grant proposals) being filled out this week by all crewmembers so that NSF grants can be submitted. At current speeds these forms easily take 20 minutes per crew member.

Telepresence, telemedicine, video conferencing all depend on reliable Internet access and a minimum bandwidth, which is much higher, than the current at sea bandwidth. With so many vital systems dependent on a strong and reliable connection to the shore, it is no wonder that there is a plea by all vessel parties to see an advancement in our current connection abilities. As industry and research continue to keep pace with the technological advancements made on shore, the research fleets need to keep pace before the gap between what is possible and what is desired becomes too large to bridge with current hacks the technicians are employing to make ends meet.

This document was shared over google drive with the ship technicians and the general experience is summed up quite well in the following quote:
“The process of filling out this google drive doc. on ‘why we need more bandwidth’ has taken me three times as long as it should due to the fact that I have been kicked off and gone through the “reconnecting…” process multiple times due to lack of bandwidth. No joke.”